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Supporting Information for

Cooling dominated cracking in thermally stressed volcanic rocks

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Calibration setup

Prior to conducting any thermal cracking experiments on the samples, we ran a series of calibration experiments to quantify the thermal gradient within the samples and the level of acoustic noise generated by the testing jig. Thermal gradient measurements were carried out using a sample modified to allow a thermocouple to be placed along its central axis in addition to the one attached to the sample surface (S2). Using both thermocouples, we were able to establish that the temperature difference across our samples was ~1°C at a heating rate of 1°C/min and ~15°C at a heating rate of 8°C/min (S3). The temperature equilibration times were ~5 minutes and ~15 minutes for the lower and higher heating rates, respectively, and thus considerably less than the 30 minutes we allowed in our thermal cracking experiments. Extraneous acoustic emission "noise" that might be generated by expansion and contraction of the components of our testing jig during experiments was characterised by heating and cooling the system using a dummy sample of soda lime glass; a material that exhibits no thermal cracking. The total AE energy generated during the test with the dummy sample was less than 1% of that generated using SB and NKD test samples (S4).

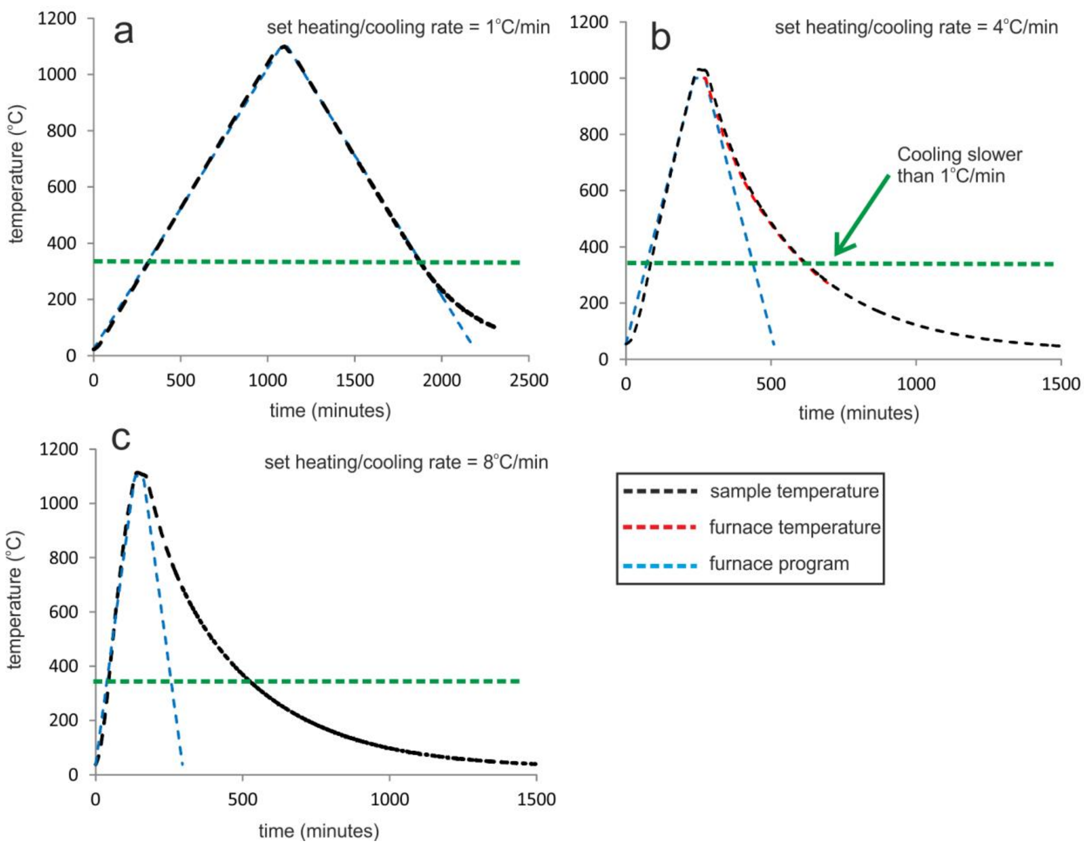

Figure S1. Programmed and actual heating and cooling profiles for a range of temperature ramp rates, A) 1 °C/min, B) 4 °C/min and C) 8 °C/min. Temperatures were measured at the sample surface. A green line indicates the temperature at which cooling rates decrease below 1 °C/min, the slowest programmed rate of cooling.

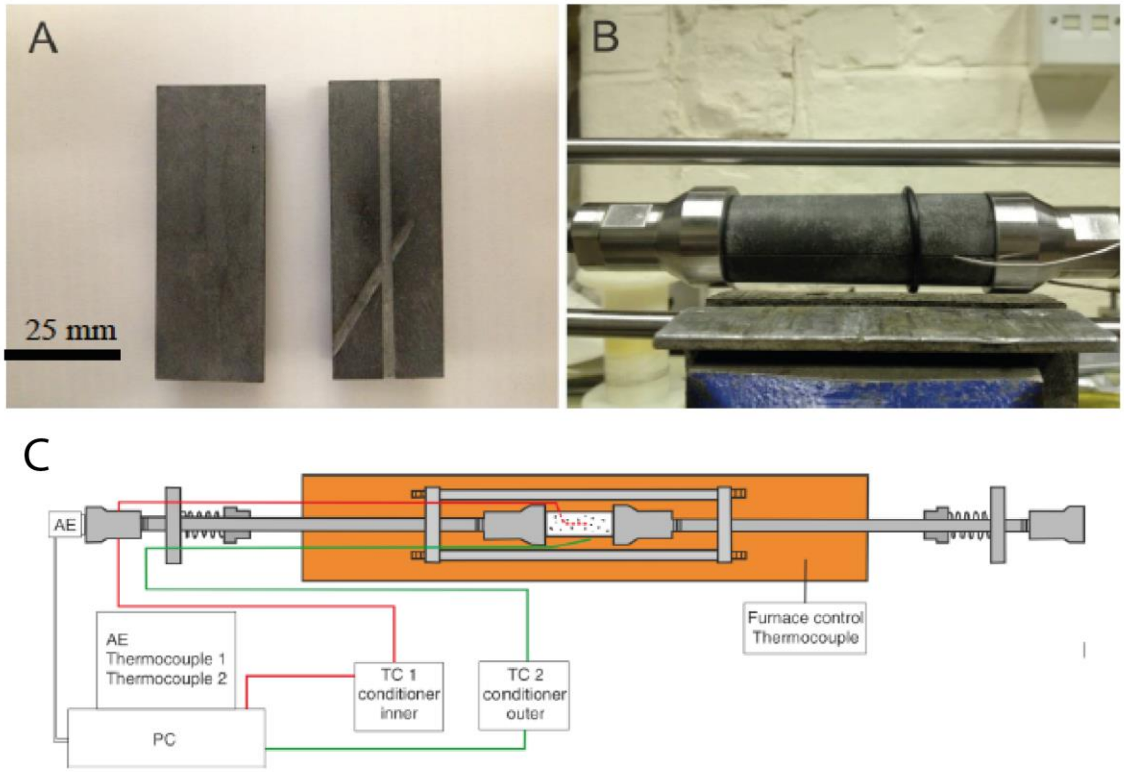

Figure S2. Sample modified to allow temperature to be measured in the centre of the sample during heat treatment. A) The sample core was cut in half with a 1.5 mm grove cut into the centre to allow the thermocouple to be placed inside, as shown in (B). C, Equipment setup for thermal calibration tests.

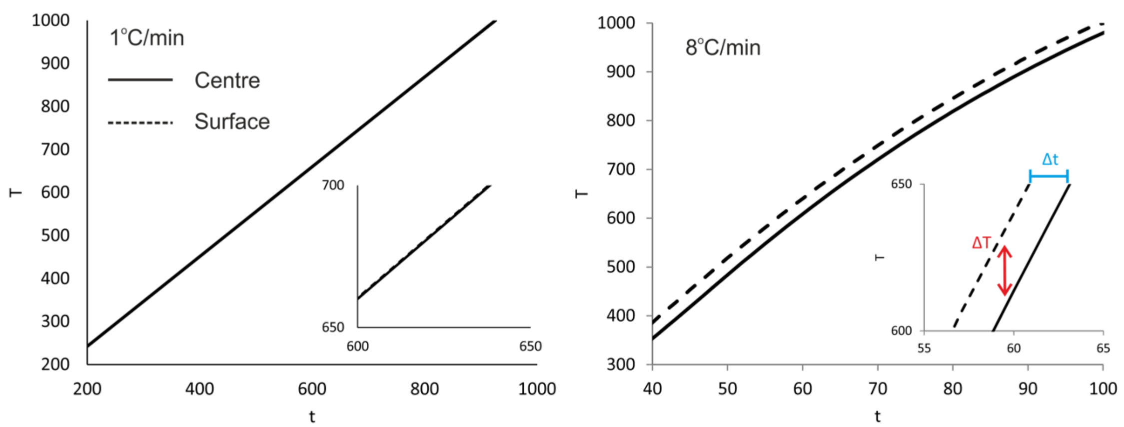

Figure S3. Measured temperature at the surface (solid line) and center (dashed line) of a modified basalt sample heated at 1 °C/min and 8 °C/min. These temperature calibrations, of which several were performed, give the radial temperature gradient as a function of heating rate and the timescale of thermal equilibration which is found to be significantly faster than 30 minutes in all tests.

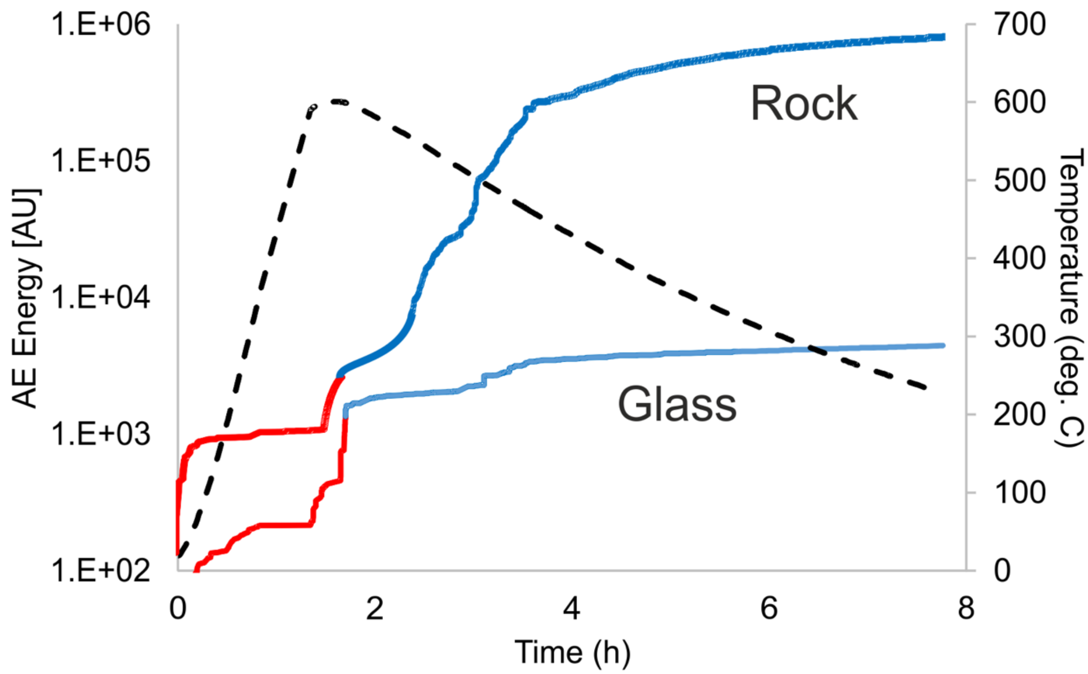

Figure S4. Acoustic emission 'noise' characterization. Comparison of AE generated by soda lime glass and Nea Kameni Dacite (rock).

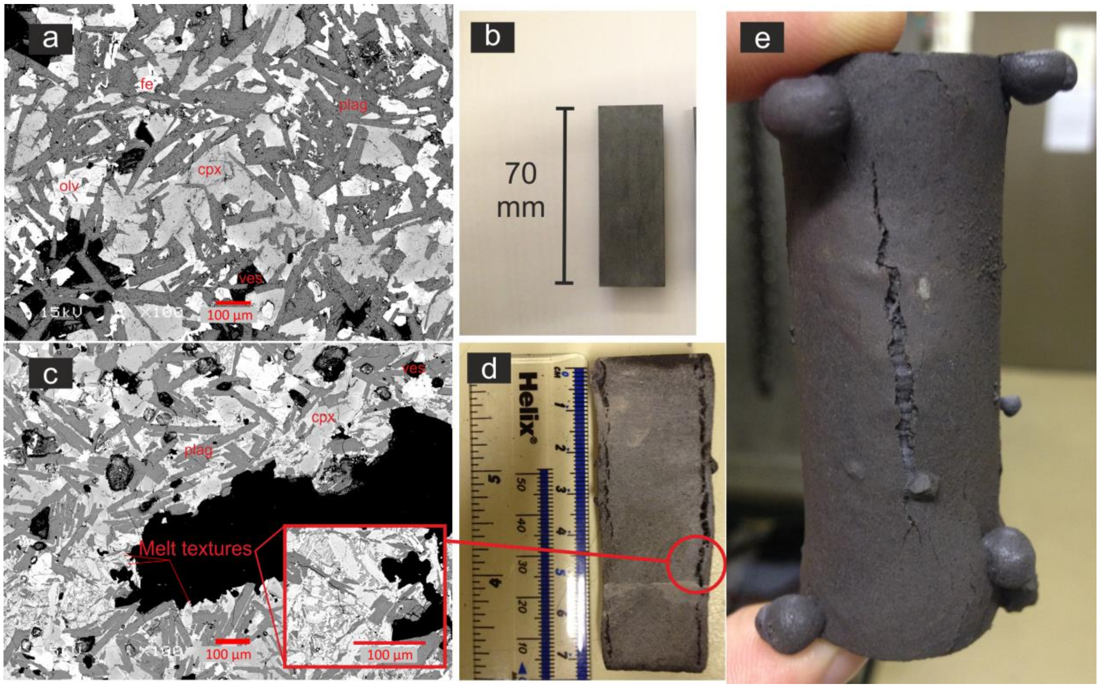

Figure S5. Macro-fracture development in a heat treated sample of SB. a) SEM image of non-heat treated SB and b) photograph of starting material. c) SEM image of a sample of SB heat treated to 1150˚C, d) corresponding photograph of end-member material. The axial tension fracture indicated by the red circle is shown in the SEM image on the left, micro-scale (<10 µm) melt textures observed under SEM can be observed around the edge of those tension fractures. In many cases melt nodules are observed emanating from tension fractures on the surface of the sample cores, as shown in e).

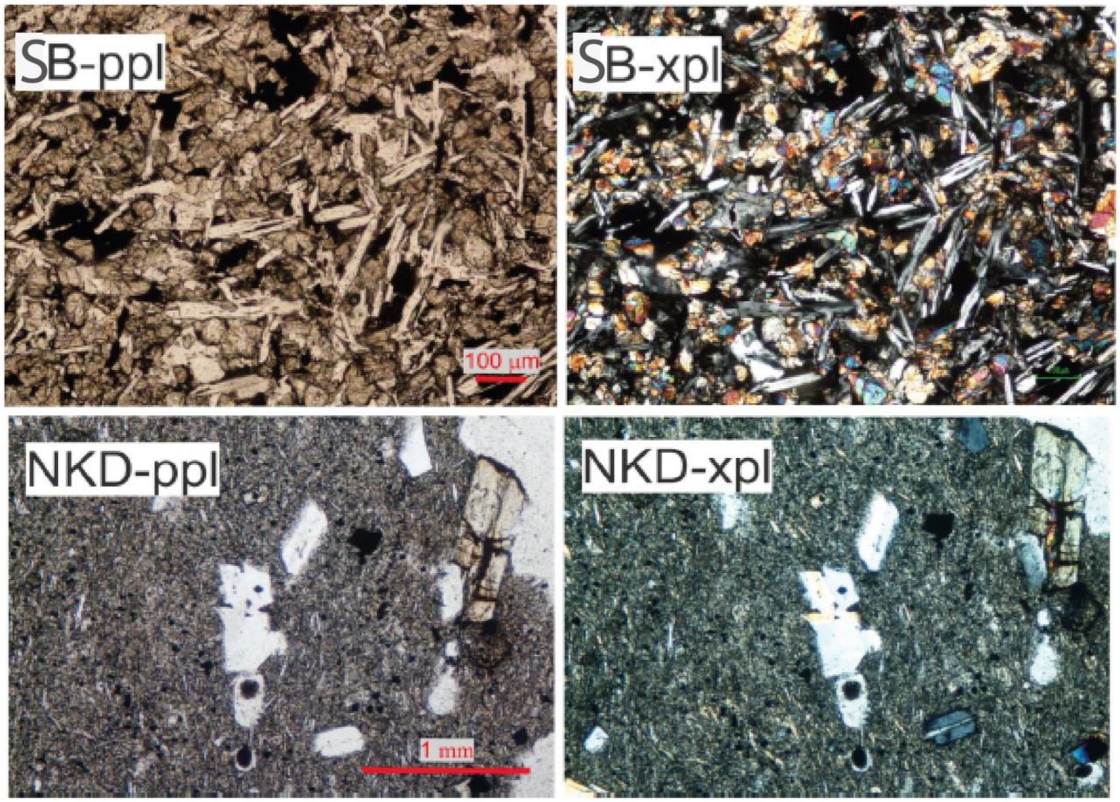

Figure S6. Optical light microscope images in ppl (left) and xpl (right), SB (top) and NKD (bottom).

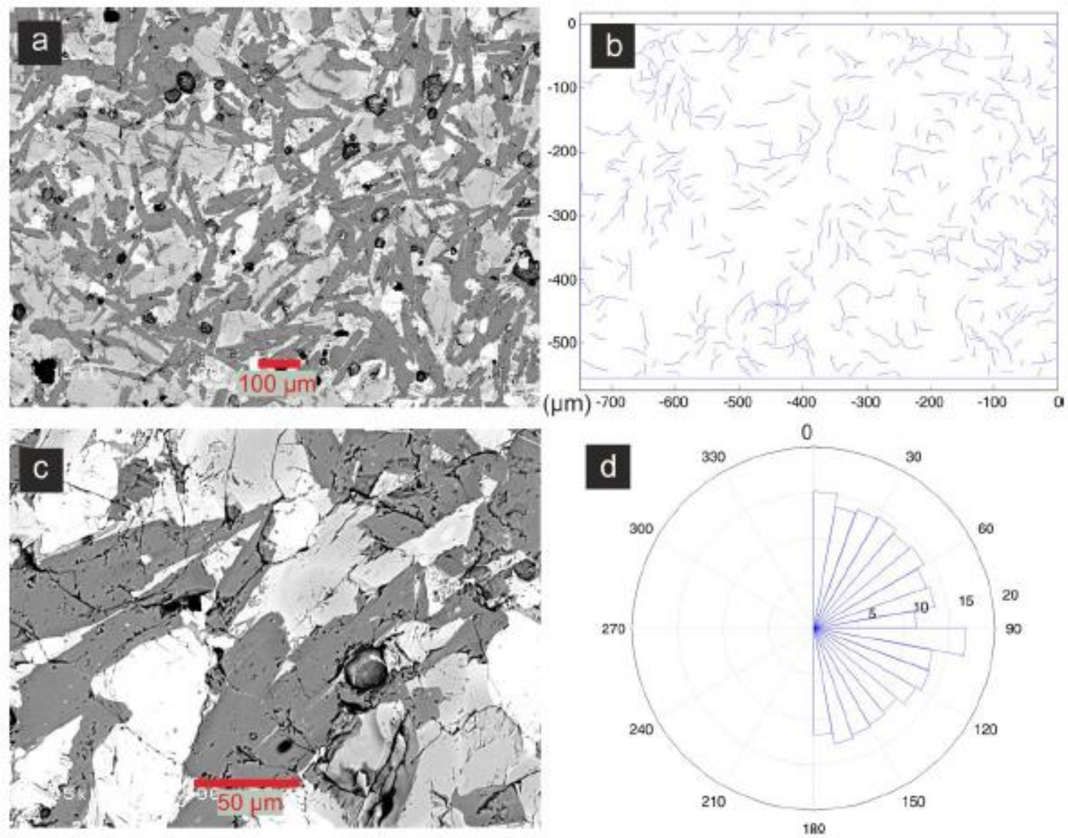

Figure S7. SEM images and crack analysis of a heat treated basalt sample. Total number of cracks measured is 418 with an average length of 82 µm ± 5 µm. a) original SEM image with scale shown, b) manually recorded crack map produced from MATLAB, c) a close-up section of the image of the above image, d) fracture numbers with respect to orientation (azimuth).

	max	min	mean	anisotropy value (A)	Vp % change
Vp (km/s)					
SB as received	5.57	5.40	5.52	0.03	42.55
SB Heat Treated	3.20	2.92	3.03	0.09	
NKD as received	5.33	5.25	5.29	0.02	21.58
NKD Heat Treated	4.18	4.05	4.15	0.03	

Table S8. P-wave velocities in Seljadalur basalt (SB) and Nea Kameni dacite (NKD) tested pre- (as received) and post-heat treatment. SB was heat treated to 1100 °C and NKD to 800 °C.